

WHAT IS CLAIMED IS:

1 1. A method for restoring audio information embodied within an analog,

2 optically-recorded variable density soundtrack of a film, comprising the steps of:

3 optically scanning the soundtrack to yield a digital signal representation of the
4 audio information;

5 storing the digital signal;

6 applying at least one statistical processing technique to the stored digital signal
7 8 to restore at least one characteristic of the audio information.

1 2. The method according to claim 1 wherein the optically scanning step

2 further comprises the step of scanning successive lines of the soundtrack.

1 3. The method according to claim 2 wherein the step of applying the at

2 least one statistical processing technique further includes performing at least one of
3 the following operations:

4 (a) averaging pixel intensities over each scanned line;

5 b) calculating a standard deviation of each pixel in each line scan, eliminating
6 pixel values that deviate above a user defined threshold, and calculating mean to
7 obtain a noise reduced instantaneous amplitude;

8 c) creating a look-up-table to correct for data values derived from non-linear
9 areas of film density transfer characteristic;

10 d) performing statistical and regression analysis of the pixel intensities values
11 to extend beyond non-linear areas of film density transfer characteristic; and

12 e) performing adaptive filtering to minimize effects of inter-modulation
13 distortion.

1 4. The method according to claim 3 further comprising the step of

2 performing one the operations in response to operator selection of said one operation.

1 5. The method according to claim 3 further including the step of performing

2 a plurality of operations.

1 6. The method according to claim 3 further including the step of performing
2 all of the operations.

1 7. The method according to claim 1 further including the step of quantizing
2 the digital signal to at least 12-bit resolution.

1 8. The method according to claim 2 further including the step of
2 synchronizing the scanning of successive lines to movement of the soundtrack to yield
3 a prescribed number of line scans per unit of time.

1 9. The method according to claim 2 wherein the step of scanning
2 successive lines of the soundtrack further comprises the step of displacing the film
3 relative to a line scan camera.

1 10. The method according to claim 9 further including the step of aligning
2 the line scan camera with respect to the soundtrack so that the soundtrack
3 substantially fills a width of the line scan camera.

1 11. The method according to claim 9 further including the step of azimuth
2 aligning the line scan camera so that equal density values of the soundtrack, when
3 displayed concurrently, appear with substantially equal brightness.

1 12. The method according to claim 9 further including the step of aligning
2 the soundtrack relative to the line scan camera so that any positional variation of an
3 audio representative envelope of the soundtrack remains within a digital image of the
4 soundtrack.

1 13. The method according to claim 3 wherein the step of creating a look-up
2 table further includes the step of mapping a linear density value to a mean amplitude
3 value if the mean value falls in a linear range.

1 14. The method according to claim 3 wherein the step of performing
2 adaptive filtering includes choosing an empirical filter value A_{ik} in accordance with
3 the formula:

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$$A_{ik} = (\sum \beta A_{k-1} \sin(wt_k + \phi) + \beta A_{k-2} \sin(wt_k + \phi) + \beta A_{k-3} \sin(wt_k + \phi) + \dots + \beta A_{k-n} \sin(wt_k + \phi)) + \\ (\sum \kappa A_{k+1} \sin(wt_k + \phi) + \kappa A_{k+2} \sin(wt_k + \phi) + \kappa A_{k+3} \sin(wt_k + \phi) + \dots + \kappa A_{k+n} \sin(wt_k + \phi))$$

1 15. A system for restoring audio information embodied within an analog
2 optically recorded variable density soundtrack of a film, comprising the steps of:

3 a optical scanner for scanning the soundtrack to yield a digital signal
4 representation of the audio information;
5 a storage system for storing the digital signal;
6 a processor for applying at least one statistical processing technique to the
7 stored digital signal to restore at least one characteristic of the audio information.

1 16. The system according to claim 15 wherein the optical scanner comprises
2 a line scan camera for scanning successive lines of the soundtrack.

1 17. The system according to claim 15 wherein the processor performs at
2 least one of the following statistical processing operations:

3 (a) averaging pixel intensities over each scanned line;
4 b) calculating a standard deviation in each line of scanned data to eliminate
5 extraneous pixel values.
6 c) calculating the standard deviation of each pixel in each line scan,
7 eliminating pixel values that deviate above a user defined threshold, and calculating
8 mean to obtain a noise reduced instantaneous amplitude;
9 d) creating a look-up-table to correct for data values derived from non-
10 linear areas of film density transfer characteristic;
11 e) performing statistical and regression analysis of the pixel intensities
12 values to extend beyond non-linear areas of film density transfer characteristic; and
13 f) performing adaptive filtering to minimize effects of inter-modulation
14 distortion.

1 18. The system according to claim 17 wherein the processor performs one or
2 the statistical processing operations in response of operator selection of said one
3 operation.

1 19. The system according to claim 17 wherein the processor performs a
2 plurality of statistical processing operations.

1 20. The system according to claim 17 wherein the processor performs all of
2 the statistical processing operations

1 21. The system according to claim 16 wherein the line scan camera yields a
2 quantized digital signal having at least 12-bit resolution.

1 22. The system according to claim 16 further including means for
2 synchronizing the scanning of successive lines of the soundtrack by the camera to
3 movement of the soundtrack to yield a prescribed number of line scans per unit of
4 time.

1 23. The system according to claim 16 further including means for displacing
2 the film relative to the line scan camera.

1 24. The system according to claim 16 further including means for aligning
2 the line scan camera with respect to the sound rack so that the soundtrack
3 substantially fills a width of the line scan camera.

1 25. The system according to claim 16 further including means for azimuth
2 aligning the line scan camera so that equal density values of the soundtrack, when
3 displayed concurrently, appear with substantially equal brightness.

1 26. The system according to claim 16 further including means for aligning
2 the soundtrack relative to the line scan camera so that any positional variation of
3 an audio representative envelope of the soundtrack remains within a digital image
4 of the soundtrack.